"Observations on the Physiology of the Cerebral Cortex of some of the Higher Apes." (Preliminary Communication.) By A. S. F. Grünbaum, M.A., M.D. Cantab., M.R.C.P., and C. S. Sherrington, M.A., M.D., F.R.S., Holt Professor of Physiology, Liverpool. Received July 20,—Read November 21, 1901.

(From the Thompson Yates Laboratory, University College, Liverpool.)

[Plate 4.]

We have been engaged for some time past on inquiry into the physiology of the cerebral cortex of the anthropoid apes. We are able to lay before the Society some new facts regarding the topographical distribution of function in the anthropoid brain. Our experiments have been carried out on individuals representing the four species *Pithecus satyrus* (Orang), *Troglodytes gorilla* (Gorilla), *Troglodytes niger* (Chimpanzee), and *Troglodytes calvus* (Chimpanzee). The specimens so far have included ten adult individuals. Of *Troglodytes niger* one individual used was only a few months old.

I. *Method employed.*

The method of excitation employed for the cortex has been unipolar faradisation, in the manner previously adoped by one of us* in examining the cortex cerebri for ocular reactions. This method allows of finer localisation than that possible with the double-point electrodes ordinarily used. The inductorium (Kronecker's pattern and scale) has been Helmholtzed.

II. "*Motor*" (*so-called*) *Area.*

This area we find to include continuously the whole length of the precentral convolution. It also enters into the whole length of the *sulcus centralis*, with the usual exception of its extreme lower tip and its extreme upper tip.

In all the animals examined, we have found the "motor" area not to at any point extend behind *sulcus centralis*. Feeble reactions can occasionally, under certain circumstances, be provoked by strong faradisation behind the *sulcus centralis*, but these are equivocal, and appear under conditions that exclude their acceptance as equivalent to "motor-area" reactions.

On the mesial surface of the hemisphere the "motor" area has extended less far down than was expected. It has not extended to the calloso-marginal fissure. Certain areas near that fissure have yielded us movements, *e.g.*, of shoulder, body, wrist, and fingers; but

* Sherrington, 'Roy. Soc. Proc.,' vol. 52, 1893.

we hesitate, for reasons to be given in a fuller communication, to class these with those of the "motor" area proper.

We have found the precentral convolution excitable over its free width, and continuously round into and to the bottom of the *sulcus centralis*. The "motor" area extends also into the depth of other fissures besides the Rolandic, as can be described in a fuller communication than the present. The hidden part of the excitable area probably equals, perhaps exceeds, in extent that contributing to the free surface of the hemisphere. We have in some individuals found the deeper part of the posterior wall of the *sulcus centralis* to contribute to the "motor" area.

In the "motor" area we have found localised, besides very numerous other actions, certain movements of the ear, nostril, palate, movements of sucking, of mastication, of the vocal cords, of the chest wall, of the abdominal wall, of the pelvic floor, of the anal orifice, and of the vaginal orifice. We have met with various examples of inhibition effects produced by this cortex, such as described by one of us previously in the cortex of the lower apes.*

We find the arrangement of the representation of various regions of the musculature follow the segmental sequence of the cranio-spinal nerve-series to a very remarkable extent. The accompanying figure (Plate 4) indicates better than can a verbal description the degree of adherence to this sequence.

We do not find that the exciting current for the "motor" cortex requires to be extremely strong for the anthropoid brain. "Epilepsy" is easily evoked from the cortex of the anthropoids.

Our experiments show that the *sulci* in the region of cortex dealt with can in no sense be considered to signify physiological boundaries. Further, the variation of the *sulci* in these higher brains is so great from individual to individual that, as our observations show, they prove but precarious, even fallacious, landmarks to the details of the true topography of the cortex.

[The mere fact that the "motor" area extends in front of but never (so far as our experiments have yet gone) behind the *sulcus centralis*, is but little indication of detailed constancy of relation between the physiological area and even that sulcus, though such a fundamental one; the antero-posterior diameter of the sulcus, being an area often five-and-twenty mm. across, it is, when treated as marking a line on the cerebral surface, but a rough guide for any detailed examination of the functional topography.—*November* 25, 1901.]

Extirpation of the hand area by itself has been followed by severe paresis of the hand, the hand being for a few days practically useless and seemingly "powerless." In a few weeks use and "power" were

* Sherrington, *ibid.*; also Sherrington and Hering, *ibid.*, vol. 62, 1897, and Hering and Sherrington, 'Pflüger's Archiv,' vol. 71, 1897.

remarkably regained in the hand, so that it was once more used for climbing, &c. The animal ultimately not unfrequently fed itself with fruit, making use of that hand alone. Even small ablations in the precentral gyrus have led to severe though quickly diminishing pareses. On the other hand, ablations of even large portions of post-central gyrus have not given any even transient paresis.

III. *Other Regions of Cortex.*

Our observations indicate that the frontal region, yielding conjugate deviation of the eyeballs, presents such marked differences of reaction from the "motor" area of the Rolandic region that we hesitate to include it with the so-called "motor" cortex; it seems necessary to distinguish it in a physiological category separate from that. Spatially it is wholly separated from the Rolandic "motor" area by a field of "inexcitable" cortex.

As to the occipital lobe, only from the extreme posterior apex of the lobe and from its actual calcarine region has faradisation yielded any movement (eyes), and then not easily.

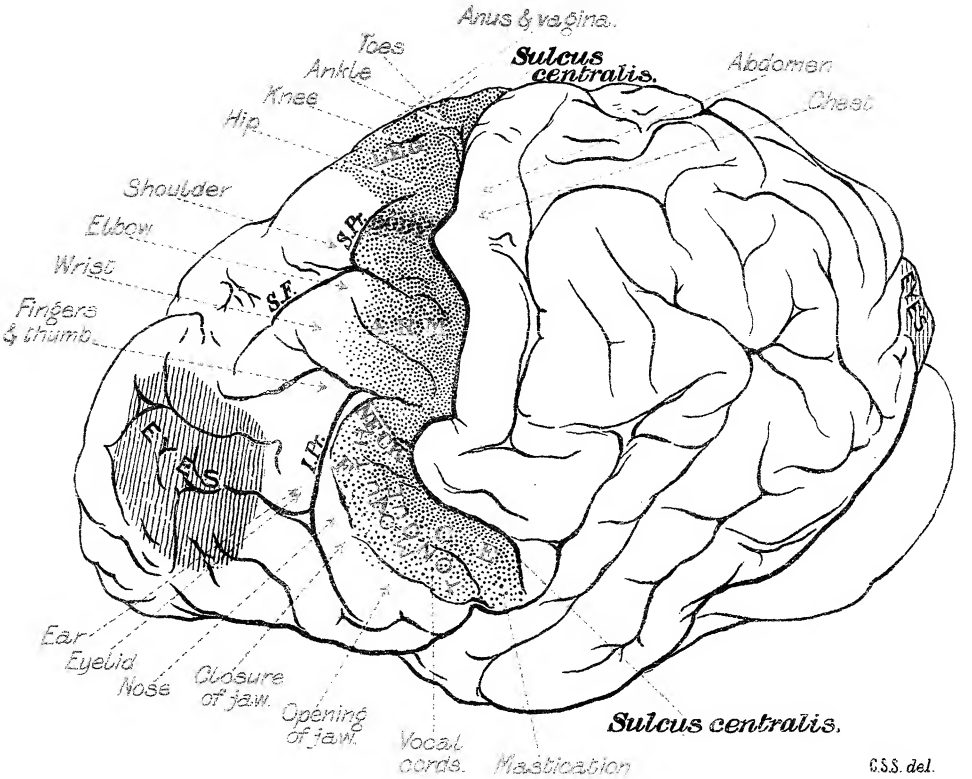
We hope at no long distance of time to be able to lay before the Society a detailed account of the completed investigation. Some of our experiments are still in progress.

It is a pleasure to record here our indebtedness to Dr. L. Mond, F.R.S., for enabling us to bring these experiments to their present stage.

DESCRIPTION OF PLATE 4.

Brain of a Chimpanzee (*Troglodytes niger*). Left hemisphere viewed from side and above so as to obtain as far as possible the configuration of the *sulcus centralis* area. The figure involves, nevertheless, considerable foreshortening about the top and bottom of *sulcus centralis*. The extent of the "motor" area on the free surface of the hemisphere is indicated by the black stippling, which extends back to the *sulcus centralis*. Much of the "motor" area is hidden in sulci; for instance, the area extends into the *sulc. centralis* and the *sulc. precentrales*, also into occasional sulci which cross the precentral gyrus. The names printed large, in *red*, on the stippled area indicate the main regions of the "motor" area; the names printed small, in *red*, outside the brain, indicate broadly by their pointing lines the relative topography of some of the chief sub-divisions of the main regions of the "motor" cortex. But there exists much overlapping of the areas and of their sub-divisions which the diagram does not attempt to indicate.

The shaded regions, marked "Eyes," indicate in the frontal and occipital regions respectively the portions of cortex which, under faradisation, yield conjugate movements of the eyeballs. But it is questionable whether these reactions sufficiently resemble those of the "motor" area to be included with them. They are therefore marked in vertical shading instead of stippling as is the "motor" area. S.F. = superior frontal sulcus. S.Pr. = superior precentral sulcus. I.Pr. = inferior precentral sulcus.


Anus & vagina.
Toes
Ankle
Knee
Hip
Sulcus centralis.
Abdomen
Chest
Shoulder
Elbow
Wrist
Fingers & thumb
S.F.
I.Pr.
Ear
Eyelid
Nose
Closure of jaw.
Opening of jaw.
Vocal cords.
Mastication
Sulcus centralis.
C.S.S. del.

Addendum on the Pyramidal Tracts. By C. S. SHERRINGTON.

The spinal degeneration resulting from ablation in the precentral gyrus of the above-mentioned "hand"-area, discovers in the anthropoid cord the human feature of a perfectly large direct ventral (Türcksbündel) as well as crossed pyramidal tract. The relative sizes of these tracts seem about the same as in man.

The homolateral or uncrossed lateral division of the pyramidal tract is also well seen. The crossed pyramidal degeneration from the hand area lesion is clearly traceable down to the lumbar region of the cord. In the lowest brachial segments there is obvious degeneration of fibres in the grey matter of the ventral horn of the crossed side. Some of the large nerve-cells there seem also degenerate.

A lesion at the top of the *gyrus precentralis* gave no ventral pyramidal tract degeneration, and only a very slight uncrossed lateral pyramidal, although an extensive crossed lateral, that descends the whole length of the cord.

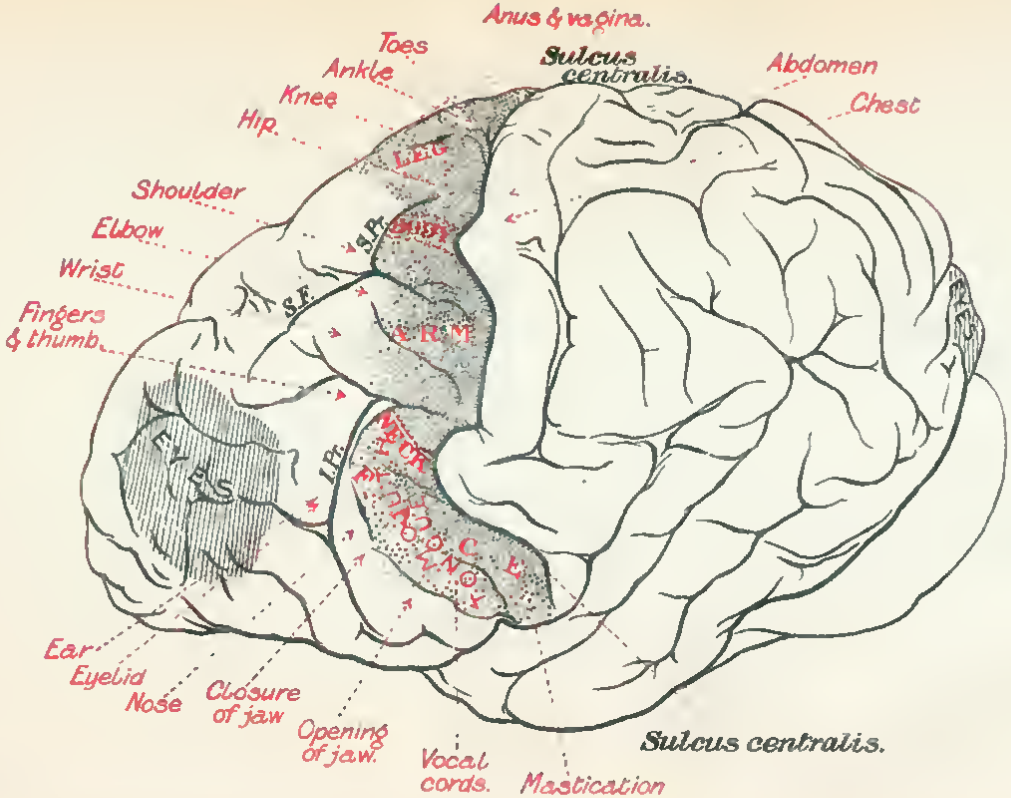
"Total Solar Eclipse of 1901, May 17–18. Preliminary Report of the Observations made at Ayer Karoe, Sawah Loento, Sumatra." By H. F. NEWALL, M.A. Received October 30,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, October 31, 1901.

This expedition was one of those organised by the Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society, funds being provided from a grant made by the Government Grant Committee.

It was originally contemplated that the party should consist of Professor H. H. Turner and myself, and that we should occupy a station inland in Sumatra; but when the former found himself unable to join in the expedition, it was decided not to appoint another observer in his stead, nor to fix upon the station to be occupied until there was an opportunity of learning about local conditions on the spot.

The expedition was to go to Padang, on the West Coast of Sumatra, and to this port I travelled in company with Mr. F. W. Dyson, who went out from the Royal Observatory, Greenwich. It was decided that we should travel out together, prepared either to join forces at one and the same camp, or to form two camps separated by a considerable distance, and our ultimate decision was to depend upon information which we expected to get from the Dutch authorities.

I had communicated with Major Muller, the Chief of the Survey



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